ELECTRICAL AUDITORY BRAINSTEM RESPONSE (EABR)

The Post-operative Electrical Auditory Brainstem Response Wave V Morphology And Latency In Cochlear Implant Patients

CNSSA 10th Annual Congress
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How do we hear?
Audiology
How hearing works
IN CASE YOU MISSED IT ......  LET'S RECAP ....
Auditory Brainstem Response (ABR)

Measurement used to predict hearing sensitivity and assess the integrity of N VIII.
Neurological Evaluation

Short-latency AEPs

Threshold Determination

Generated in the brainstem

Click’s 2000-4000Hz Air & Bone

Tone bursts Frequency specific Air & Bone

CE-Chirp Frequency specific Air & Bone

Auditory Steady State Response (ASSR) Frequency specific

Frequency specific Click’s 2000-4000Hz Air & Bone

Frequency specific Tone bursts Air & Bone

Frequency specific CE-Chirp Air & Bone

Frequency specific Auditory Steady State Response (ASSR)
Neurological evaluation
The ABR is generated in the brainstem and tests the integrity of the VIII\textsuperscript{th} cranial nerve (retrocochlear conduction).

Tests only between 2000-4000Hz.
Limitation of Click-Evoked ABR: Lack of Frequency-Specificity

With permission – J Hall 2005
Frequency specific ABR (Tone Bursts)
BUT WHAT IF....!
Auditory Steady State Response (ASSR)

- Brain Evoked Potential

- The Auditory Steady-State Response (ASSR) is a periodic electrical response from the brain, evoked by a periodic varying continuous acoustic signal, typically a sinusoidally modulated tone.

- Response used to predict a behavioural audiogram

  (ASSR is a tool that is used to predict behavioral auditory threshold levels)
Trials done

Estimated audiogram
Remember......!

- ABR IS NOT A STAND ALONE TEST, PART OF A TEST BATTERY!
Hearing Aids

Cochlear Implant
Cochlear Implant (CI) History and “useless information”

- **1950** - first demonstrated in Paris in the 1950s by André Djourno and Charles Eyriès.

- **1957** - They implanted the first auditory prosthesis – single channel.

- **1960** - William F. House collaborated with two Doyle brothers (one was a neurosurgeon and the other an electrical engineer) on devising a cochlear implant for humans – single channel.

- **1975** - National Institute of Health sponsored a thorough evaluation of patients who have received single-channel cochlear implants.
1978 - Rod Saunders, first multichannel cochlear recipient
After his sound processor was turned on, Rod excitedly jumped up and saluted, indicating that he could hear "God Save the Queen" being played to him. It works! Clinical data from Rod's implant helps drive the cochlear implant industry.

1979 – Rod uses a portable speech processor

https://www.cochlear.com/au/about/company-history
■ **1980** - Second recipient, George Watson

Portable speech processor with magnet-less headset is created.

■ **1984** - Multiple-channel devices were introduced

■ **1985** - Multi-channel devices approved for implantation

■ **1985** - 1st Two paediatric implants

https://www.cochlear.com/au/about/company-history
2002 - Product innovation

Unique Soft-tip feature designed to protect the delicate cochlea structures.

Latest development – does not damage hair cells still present or even the residual hearing.

https://www.cochlear.com/au/about/company-history
2 Techniques to test the cochlear implant
Aided ASSR with cochlear implant

6yrs old child
Aided ASSR right ear
Cochlear implant (Nucleus 24)

4yrs 6 months old child
Aided ASSR right ear
Cochlear implant (Nucleus Sprint)
Electrical Auditory Brainstem Response (EABR)
What is an EABR?

- The EABR is a measurement of the ABR using an electrical stimulus.

- EABR measures the response of the auditory nerve and brainstem as a result of electrical stimulation through a cochlear implant.

- Measures action potential and post-synaptic response of auditory system.

- The EABR is a measure of peripheral neural responsiveness.

- Measures synchronicity of auditory system in response to an electrical stimulus.
Purpose of an EABR...

Pre-operatively
- To assess the function of the remaining auditory nerve fibres.
- To determine the site of the auditory nerve lesion.
- Assessment of surviving neural elements of the auditory pathways.
- To determine the electrical excitability of an ear considered for implantation.
- When suspecting the absence of a cochlear nerve.

Intra-operatively
- Can be performed at the time or at the completion of implant surgery to evaluate both the functioning of the cochlear implant and the stimulation of the auditory pathways.
Post-operatively

- As an objective measure of the electrical threshold and comfort levels when initially setting the external processor.
- Monitoring long-term function of the eighth cranial nerve and auditory central nervous system following implantation.
- Quantifying the integrity of the eighth cranial nerve.
- Evaluating cochlear implant performance and the patient’s communication success with the implant.
- Assessing the implants function in patients with temporal bone anomalies and patients with auditory neuropathy spectrum disorder.
- Help assess the frequency specific probabilities of the auditory nerve.
The Post-operative Electrical Auditory Brainstem Response Wave V Morphology And Latency In Cochlear Implant Patients
Objectives of the M study were…….

■ The primary objective was to assess the occurrence of Wave V at the different cochlear stimulation sites namely, apical, medial and basal.

■ The secondary objective was to assess whether there are statistically significant absolute latency differences in wave V with different cochlear stimulating sites (apical, medial or basal).

■ The third (final) objective was to determine whether the presence of wave V can provide an indication of whether the implant is functioning optimally (“good” versus “bad” user).
Study population

- 18 persons were tested of whom 6 participants had bilateral implants (thus a total of 24 ears).

- There were nine females and nine males with an age range of 18 to 67 years.
Aetiology

- Progressive - unknown: 39%
- Meningitis: 17%
- Congenital - unknown: 11%
- Rubella: 11%
- Noise induced: 5%
- Progressive - genetic: 5%
- Congenital - genetic: 6%
- Jaundice after birth: 6%
Method

- Equipment requirements
- Equipment set-up (stimuli, recording, interface)
- Electrode montage
- Pt set-up & instructions
- **Stimulus**

- **Recording**: recorded randomly from the three cochlear regions namely apical - electrode twenty one (E21), medial - electrode sixteen (E16) and basal - electrode three (E3)

- **Interpretation**

  - Apical = E23 – E18
  - Medial = E17 – E8
  - Basal = E7 – E1

*Source: http://resource.isvr.soton.ac.uk/soecic/CI_des.html*
Examples of EABR

- **E21**
- **E16**
- **E3**
The primary objective was to assess the occurrence of Wave V at the different cochlear stimulation sites namely, apical, medial and basal.

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Number and proportion of ears with a wave V response</th>
<th>95% confidence interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical - E21</td>
<td>19 (79%)</td>
<td>60.9 ; 97.5</td>
</tr>
<tr>
<td>Medial - E16</td>
<td>19 (79%)</td>
<td>60.8 ; 97.5</td>
</tr>
<tr>
<td>Basal - E3</td>
<td>5 (21%)</td>
<td>2.5 ; 39.2</td>
</tr>
</tbody>
</table>

Wave V was properly identifiable at both the apical (E21) and medial (E16) electrode sites, which makes it more suitable to use electrodes in those specific regions for assessing the nerve with EABR tests.
Results

- The secondary objective was to assess whether there are statistically significant absolute latency differences in wave V with different cochlear stimulating sites (apical, medial or basal).

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>N</th>
<th>Mean (ms)</th>
<th>95% confidence interval (ms)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical - E21</td>
<td>19</td>
<td>4.30</td>
<td>4.20 - 4.40</td>
<td>-</td>
</tr>
<tr>
<td>Medial - E16</td>
<td>19</td>
<td>4.35</td>
<td>4.25 - 4.45</td>
<td>0.211</td>
</tr>
<tr>
<td>Basal - E3</td>
<td>5</td>
<td>4.37</td>
<td>4.22 - 4.51</td>
<td>0.302</td>
</tr>
</tbody>
</table>

- Basal portion of the electrode array can be omitted from the EABR assessment.
The third (final) objective was to determine whether the presence of wave V can provide an indication of whether the implant is functioning optimally (“good” versus “bad” user).

A “good” or “bad” is a classification established by a speech discrimination (SD) test done by an audiologist.

A “good” user was a person who understood spoken language correctly for 60% of the time using their cochlear implant.

A “bad” user was a person who understood spoken language correctly less than 60% of the time using their cochlear implant.

The audiologist indicates on the patients file whether the patient is a “good” or “bad” user of the cochlear implant.
Wave V was present in 90% of the participants that have been classified by the audiologists as a “bad” user.

This is a slightly higher presence than the 87% that were found in the “good” users.
In one of the participants that was classified as a “good” user, no responses could be elicited at all three different electrode sites.

The statistical outcome was that the presence of wave V does not indicate whether the implant is functioning optimally, meaning distinguish between a “good” versus a “bad” user.

Even so, when a patient has poor outcomes after the cochlear implant, it must be determined if the cause is due to patient limitations (e.g. cognition, developmental delay) versus device integrity.

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Wave III present</th>
<th>Wave V present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical - E21</td>
<td>5 (62%)</td>
<td>7 (87%)</td>
</tr>
<tr>
<td>Medial - E16</td>
<td>4 (50%)</td>
<td>7 (87%)</td>
</tr>
<tr>
<td>Basal - E3</td>
<td>1 (12%)</td>
<td>3 (37%)</td>
</tr>
</tbody>
</table>
Limitations of the study

- The time constraint was a major challenge, due to the subject’s unwillingness or due to external factors, to stay for longer periods at the practice where EABR recordings were performed.

- The current level of stimulation could not be set higher due to participants experiencing severe pain, the facial muscles started twitching or the eye started tearing.

- The exact position of the implant array in the cochlea could not be established.

- The relatively small sample size (18 subjects with 24 ears tested), could have been addressed by prolonging the study and involving the other cochlear implant teams to recruit more subjects.

- Nonetheless the number of ears tested is comparable to several previous published studies.
Conclusion

- EABRs are not done as a routine test during cochlear implantation, and very few post-operatively EABRs are done in South Africa.

- This could be addressed by incorporating the test battery procedures and relevance of the EABR during the training of the different professionals.
EABR examples of actual patients
Questions & Answers